III. REMARKS

Double Patenting Rejection

Claim 1 stands provisionally rejected on the grounds of non-statutory obvious-type double patenting over claim 4 of co-pending application 10/912,820; claims 1 and 10 stand provisionally rejected over claims 1 and 9 of co-pending application 10/756,652. The applicants have entered herewith a terminal disclaimer in respect of both applications that obviates this rejection.

Statutory Rejections

Claims 1 and 2 stand rejected under 35 U.S.C. 103(a) as obvious in view of U.S. Patent 6,767,530 ("Kobayashi") or alternatively U.S. Patent 2,556,835 ("Barr"). These rejections are respectfully traversed in part. Simply stated, Kobayashi teaches a combination of two well-known processes (1) regenerative bed reforming, and (2) pressure swing adsorption. Kobayashi teaches conventional steam reforming, col. 3, lines 1-10, 21-30, bed heat regeneration, lines 11-20 and 42-52 (1st regeneration bed), optional water shift reaction, lines 53-67, second heat recovery bed, col. 3, line 61, followed by conventional pressure swing adsorption, i.e. gases other than hydrogen are absorbed by adsorber 10 at high pressure, while hydrogen passes out of the system. The system is then depressurized, releasing the adsorbed gases that are purged with "tail gas" supplied to the system. The pressure swings, required by Kobayashi to perform PSA, are accomplished by controlling the flow rates of feed stream and hydrogen removal. At least in respect of regenerative bed reforming, Kobayashi adds nothing to the then state of the art, best represented by U.S. Patent 4,240,805.

In contrast, the present inventors have discovered that efficient regenerative bed reforming is accomplished by conducting the reforming step at a significantly higher

space velocity than taught in the art. Applicants' amended claims include the limitation that its reforming step be conducted at a space velocity of at least 1000 hr^{-1}, which is about an order of magnitude higher than the state of the art. Kobayashi is silent in respect of the space velocity of its reforming, not having recognized its importance to the efficiency of the reforming process.

Barr illustrates just how old the basic concept of regenerative heating reforming is. In this 1945 patent, the inventors describe using the reforming fuel to combust and heat other reforming beds for their reforming heat needs. Like Kobayashi, Barr is silent with respect to the reforming process space velocity. Like Kobayashi, Barr failed to achieve the efficiencies needed for successful application of this technology. Like Kobayashi, Barr does not teach reforming at high space velocity.

Applicants respectfully submit that neither Kobayashi or Barr render obvious the applicants' invention as set forth in the amended claims 1 and 2.

Claims 3-8 stand rejected under 35 U.S.C. 103(a) as unpatentable over Kobayashi in view of Barr and U.S. Patent 6,299,994 ("Towler"). This rejection is respectfully traversed in part.

Kobayashi and Barr have been addressed above. The additional reference, Towler, combines partial oxidation with reforming, followed by a shift reaction to produce hydrogen for a fuel cell. Towler teaches a conventional approach toward heat integration to increase efficiency, i.e. positioning all heat requiring reaction zones near exothermic reactions (see col. 12 lines 27 et seq.). While heat integration plays an important role in the regenerative reforming taught in the present invention, it is necessary but insufficient to achieve high efficiency reforming. Towler, like both Barr and Kobayashi fail to recognize the high space velocity taught in the present invention.

Applicants respectfully submit that Kobayashi, in view of Bar and Towler, neither teaches nor suggests the invention set forth in applicants' amended claim.

Claim 9 stands rejected under 35 U.S.C. 103(a) over Kobayashi, or alternatively over Barr in view of U.S. Patent 6,338,239 ("Hirata"). This rejection is respectfully traversed in part. For at least the reasons stated above, claim 9, which incorporates all limitation of claim 1, is not taught nor rendered obvious by Kobayashi. Applicants acknowledge that Hirata teaches a turbine coupled with a regenerative bed reformer; however fails to teach or suggest conducting reforming and regeneration at high space velocity as specified in applicants' amended claims. Therefore, applicants respectfully submit that neither Kobayashi, nor Barr in view of Hirata teach or suggest the invention set forth in applicants' amended claims.

Claims 10-15 and 17 stand rejected under 35 U.S.C. 103(a) over Kobayashi in view of Barr, and Towler, and U.S. Patent 4,240,805 ("Sederquist"). This rejection is respectfully traversed in part. Although applicants have above described the characteristics that distinguish their invention from the teachings of Kobayashi, Barr and Towler, they wish to here address the Examiner's contention that "Although Kobayashi et al. does not specifically disclose carrying out the method in a 'pressure swing reformer', the process carried out appears to be substantially similar. Additionally, Kobayashi et al. teach that the pressure of the process can be elevated to a desired level by controlling flow rates of the feed streams and product streams (col. 4)."

Kobayashi teaches pressure swing adsorption (not pressure swing reforming as taught herein). Kobayashi varies the "Process" pressure simply to perform the known process of pressure swing adsorption. He does so by simply "controlling the flow rates of the feed streams 1 and 4 and product stream 11 of the process." Kobayashi's varying pressure in the PSA part of its process by controlling gas-in vs. gas-out in no manner

teaches or suggests, nor inherently performs the process of pressure swing reforming taught herein which is accomplished by controlling <u>space velocity</u>.

Turning now to U.S. Patent 4,240,805, Sederquist represents the closest prior art in the view of applicants. Sederquist teaches a cyclic reforming and reheating process for reforming a hydrocarbon and steam feed. Sederquist postulated that reforming systems efficiency could approach 97%, though as exemplified in the patent were only able to achieve efficiencies of about 70%. The inventors here have discovered the key to achieving the high efficiency in regenerative reforming, sought by Sederquist but never attained. Despite the passage of twenty some years, neither Sederquist (nor others) have achieved such efficiencies in regenerative reforming.

<u>Sederquist Space Velocity Calculation</u>

Space velocity is generally represented as (standard volume/hr feed)/(volume catalyst beds). In this analysis and in the application, the feed is represented in terms of its C_1 (Carbon one) content Thus, C_1GHSV is determined.

In column 12 line 52, Sederquist's reactor is described as 8 feet in diameter "including internal insulation". In column 11 line 57-60 the subscale reactor is described as being "six feet long in diameter". Since no insulation is indicated the skilled reader would understand four inches to be the internal diameter, which is thus the diameter of the catalyst bed. The subscale reactor is described at lines 60-61 as having air tube 114 "two inches in diameter". These assumptions are confirmed by figure 4, ie. the outside diameter of the air tube is one half the inside diameter of the reactor.

Thus, taking the volume as the entire bed system, the volume of a cylinder 4 inches in diameter and six feet long (column 11 line 49) is 0.524 ft^3. These are the volume measurements of the reactor vessel 102.

At column 12 line 26 the feedstock is described as "naphtha (atomic hydrogen to carbon ratio of 1.89)". From this it can readily be calculated that the feed contains 84.6 wt% carbon.

At column 12 line 38 the flowrate is given as 1.87 lb/hr. This corresponds to a carbon rate of 1.58 lb/hr, which is a C_1 rate of 0.132 lb-moles/hr, or a C_1 standard volume rate of 47.3 ft^3/hr.

From these figures C_1GHSV is determined as (47.3/0.524) = 90.3 hr^{-1}.
At column 1 line 57-61, a second experiment is carried out at a flow rate of 2.0 lb/hr. No feedstock carbon or hydrogen content is given for the "No. 2 fuel oil" feed but Perry's Chemical Engineering Handbook (6th edition, McGraw Hill) on page 9-10 gives a typical content as 87.3% carbon, 12.6H hydrogen and 2200 ppm sulfur (all on a weight basis). Using this data the second example represents a C_1 standard volume rate of 52.2 ft^3/hr and thus C_1GHSV is determined as 99.7 hr^{-1}.

Hence, Sederquist teaches space velocities of 90-100 hr^{-1}.

<u>Solution to the inefficiency problem</u>

Note that at column 12 lines 44 *et seq* Sederquist indicates a measured efficiency of only about 70% is achieved, due to large heat losses. He suggests that this can be improved by better insulation and improved heat transfer during regeneration. He speculates that this might improve efficiency to 97% but the improvement is not demonstrated.

It is important to note that Sederquist states improved efficiency might be obtained by "well known procedures" (column 12 line 48). Nowhere does Sederquist suggest that higher space velocities might improve efficiency. Quite the contrary, in the scale-up suggested at column 12 lines 50-56 indicates that increased cross section should be used relative to the subscale apparatus. From the figures given, the skilled reader would understand that Sederquist is suggesting that bed volume should be increased by a factor of about 960 so as to accomplish a flow rate increase of about 1000 times. That clearly is scaling up at substantially constant space velocity.

Kobayashi, Towler and Hirata did not advance the art of regenerative reforming; they represent the addition of PSA, heat integration and turbine technology to regenerative bed reforming. None recognize the invention contribution to the art contained in the present invention and believe the answer to the longstanding challenge of imposed efficiency.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

Respectfully submitted,

Paul E. Purwin
Attorney for Applicant(s)
Registration No. 29,203
Telephone Number: (908) 730-3618
Facsimile Number: (908) 730-3649

[X] Pursuant to 37 CFR 1.34(a)

ExxonMobil Research and Engineering Company
P. O. Box 900
Annandale, New Jersey 08801-0900

PEP:dws
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